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A Study on Green Cloud Frameworks and Elastic Resource Management Challenges in Cloud Computing Environment

Dr.M.Chidambarm[1], *Mr. R.Shanmugam[2]
[1]*Assistance Professor, Department of Computer Science, Rajah Serfoji Government College, Thanjavur, Tamil Nadu, India.*
[2]*Assistant professor, Department of Computer Science, Arignar Anna Govt. Arts and Science College, Karaikal, Puducherry, India.*
Corresponding Author: R.Shanmugam[2]

Abstract: *The emergent need to reduce the huge investment cost on computing resources and the awareness about global warming have moved the traditional IT paradigm to shift towards green cloud computing paradigm. By using cloud enabled technologies, users utilize IT resources on a rental basis with an on-demand elastic manner instead of purchasing the IT resources. Elasticity is one of the key characteristics of Cloud computing which supports to access resources in a green aware elastic manner. Realizing the significance of the green awareness and elasticity in cloud computing IaaS environment, this paper affords comprehensive analysis about green aware elastic resource management. Moreover, this paper discusses the various challenges related to elastic resource management in cloud computing environment with green awareness and the future research directions are also investigated.*

Keywords: *Cloud Computing, Elasticity, Resource Management, Green Cloud, Infrastructure*

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I. Introduction

Traditionally, computing resources are purchased by various organizations for running their business. Nowadays, the computing resources are rented with the support of Cloud Computing. Cloud Computing changes the business environment with the on-demand elastic approach. Gartner report [1] stated that the aggregate amount of shifting of traditional IT services to cloud services is expected to attain $216 billion in 2020 whereas $111 billion is estimated in 2016. Especially in IaaS, the cloud shift rate will be increased 17% in 2020.

National Institute of Standards and Technology (NIST) states [2] that "Cloud Computing is a model for enabling convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction". NIST named the five necessary characteristics of cloud computing are on-demand self-service, broad network access, resource pooling, rapid elasticity and measured service. Generally, cloud computing provides three kinds of service such as Infrastructure as a Service (IaaS), Platform as a Service (PaaS) and Software as a Service (SaaS). Private Cloud, Public Cloud, Hybrid Cloud and Community Cloud are the deployment models used in cloud.

Accessing computing resources in an on-demand elastic manner is one of the primary reasons to adopt cloud computing. Hence, Elasticity is an inevitable and powerful feature of Cloud computing paradigm. It indicates the power to dynamically increase or decrease computing resources based on the cloud user's demand. Various definitions for the term 'Elasticity' were found in the literature and some of the standard definitions are given the Table 1.

Table 1: Elasticity Definitions

Authors	Definition
NIST [3]	"Rapid elasticity: Capabilities can be elastically provisioned and released, in some cases automatically, to scale rapidly outward and inward commensurate with demand. To the consumer, the capabilities available for provisioning often appear to be unlimited and can be appropriated in any quantity at any time".

N. R. Herbst et. al [4]	"Elasticity is the degree to which a system is able to adapt to workload changes by provisioning and deprovisioning resources in an autonomic manner, such that at each point in time the available resources match the current demand as closely as possible."
Reuven Cohen et. al [5]	"The quantifiable ability to manage, measure, predict and adapt responsiveness of an application based on real time demands placed on an infrastructure using a combination of local and remote computing resources."
Wei Ai et. al [6]	"The elasticity E of a cloud perform is the percentage of time when the platform is in just-in-need states; that is, $E = T_j/T_m = 1 - T_o/T_m - T_u/T_m$."
L. Badger et. al [7]	"The ability of customers to quickly request, receive, and later release as many resources as needed."

Figure 1: Various Tasks of Resource

Management

Elasticity is differed from Scalability in the aspect of capacity planning, manual support and dynamic workload changes. The Figure2 shows how cloud elasticity varies from scalability [8].

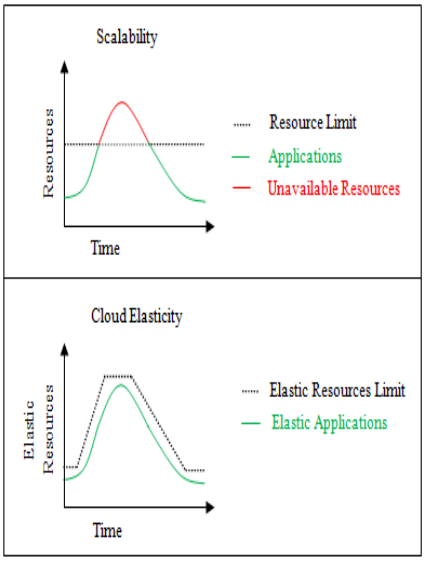

Figure 2: Scalability Vs Cloud Elasticity

Ensuring elasticity in cloud resource management is one of the major important challenges in cloud computing environment. The elastic resource management deals with providing and sharing resources in an on-demand basis. It can offer various benefits explicitly namely energy efficiency, efficient resource utilization, load balancing, SLA violation reduction, reduce operation cost, etc. These benefits can collectively enhance the

reliability of the Cloud IaaS Service. In order to ensure the cloud elasticity, the resource management focuses on tasks such as resource provisioning, resource allocation, resource adaptation, resource mapping and resource scheduling. Figure 3 shows the classification of the Cloud Resource Management Techniques based on objectives along with various Performance Metrics. Moreover, it can also lead to green aware cloud computing by providing elastic workload integration and reducing the impact of carbon emissions. Generally, power aware and thermal aware concepts are available in green aware super computing systems. Thermal aware concept focuses the entire temperature level of datacenter whereas the power aware concept concentrates on resource usage on server in a datacenter [9] [10]. Cloud enabled green computing features are dynamic provisioning, multi-tenancy, server utilization and datacenter efficiency [31].

The remaining section of this paper is organised as follows: Related works are presented in Section II. Section III describes the kinds of green aware cloud elastic resource management challenges in cloud. Conclusion and future directions are presented in section IV.

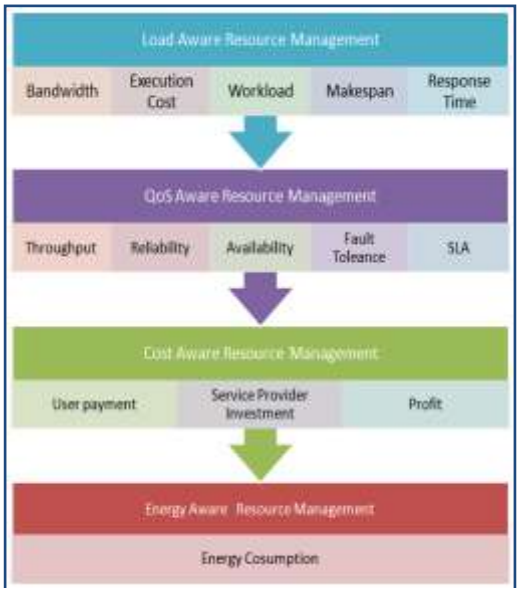

Figure 3: Classification of Cloud Resource Management Techniques

II. Related Works

Recently, due to globalization, the usage of datacenters is dramatically increased. In order to improve resource utilization with the minimal number of cloud servers and to minimize energy consumption, Green cloud computing plays the essential role in IT industry [11] [12].Table 2 shows the various frameworks or architectures proposed for green cloud computing in the existing research works. Truong Vinh Truong Duy et al. [13] presented the green scheduling algorithm which used neural network oriented predictor for minimizing energy consumption in cloud computing environment. Based on the historical data, the future load demand is predicted by the predictor. In order to minimize the energy in all levels the green scheduling algorithm turns off idle or unused servers with the support of predicted values. Jorge Werner et al. [14] proposed an integrated green cloud infrastructure management solution for environment, networks and services. To make green cloud with the aim to reduce the CO2 emission and power consumption, BhanuPriya et al. [15] discussed energy efficiency, energy models metrics. The three important factors such as virtualization [34], workload distribution and software automation were taken into account to make the green cloud by the authors. To make environment safety with the support of Green Computing which effectively use the computing resources [16]. The resources energy efficient CPUs, storage, Servers, minimize resource consumption and better way of electronic waste disposal. NimishaJoy et al. [17] proposed an approach which includes the energy aware parameters in Service Level Agreements for reducing high energy consumption in cloud computing environment. The authors focused on the development of green SLA, in order to improve the energy efficiency of cloud system during the high workload at peak hours, without affecting the availability. Felipe Fernandes et al. [11] presented a virtual machine scheduling algorithm to reduce the energy usage, to minimize SLA violations, to apply VM allocation policy and to avert performance losses in homogeneous HPC (High Performance Computing) cloud computing environments. Huangke Chen et al. [18] proposed PRS (Proactive and Reactive Scheduling) algorithm to improve energy efficiency for periodic independent tasks in cloud datacenter. Based on the uncertainty of the cloud computing system, the PRS algorithm focuses on the real-time task scheduling and computing resources by combining proactive and reactive scheduling methods. Moreover, the proposed scaling strategies for

computing resources are based on the on-demand user workload. Elias De Coninck et al. [19] proposed a model driven approach which focused on multiple interdependent tasks for dynamic scaling. The proposed framework contains the workflow service, knowledge model, adaptive planning and scheduling components.

Anton Beloglazov et al. [20] defined energy efficient cloud computing framework and principles for minimizing the operational cost and reducing environmental impact. J. Octavio Gutierrez-Garcia et al. [30] proposed a group of 14 scheduling heuristics for elastic cloud bag-of-tasks with concurrent execution. They had used agent based cloud architecture which is composed of BoT scheduler, Cloud directory, service ontology, consumer agents, middle agents, service provider agents and resource agents. Even though, there were few research works concentrated on the Green Cloud Computing, each of these existing works have some limitations. Further, it is also observed from the Table 2, the works were not concentrated on green aware elastic oriented cloud framework in cloud computing environment.

Table 2: List of Various Existing Green Cloud Architectures

Author Name and Reference Number	Year	Proposed Framework	Goal	Techniques Used
Liang Liu, et.al [24]	2009	GreenCloud Architecture	Reduce energy consumption of datacenter	Live Vm Migration, Online Monitoring Services, Data Services, Virtual Machine Placement Optimization, Managed Environment
Lefevre L, et. al [25]	2010	Energy Efficient Framework	Analyze energy in virtualized environment	Green Open Cloud, Monitoring Idle server
Andrew J. Younge, et. al [29]	2010	Green Cloud Framework	Improving system efficiency, minimizing operational cost	Greedy based Virtual Machine scheduling, Image management of VMs, Data Center Design
Buyya, et. al [23]	2011	Carbon Aware Green Cloud Architecture	CO2 emission reduction, minimize overall energy consumption	Carbon Efficient Green Policy (CEGP), Green Offer Directory and Carbon Emission Directory
Chen Lin [21]	2012	Novel Green Cloud Framework	Improving system efficiency	Energy Efficient Scheduling, Service Oriented VM Image
Mohammad NaiimHulkury, et. al [26]	2012	Integrated Green Cloud Architecture	Access services in the greenest way	Client-oriented Green Cloud Middleware, Green Cloud Broker Layer, Manager Component, User Component
Ahad Abdullah [27]	2012	Green Cloud Framework	Controlling energy consumption of cloud	Green Broker, Carbon Emission Directory, Green Cloud Offers
K. Palanivel [28]	2014	Cloud-Oriented Green Computing Architecture	Green aware E-learning Applications which focused energy consumption reduction, access needed software	Layers: Infrastructure Layer, Software Resource Layer, Service Layer, Resource Management Layer
DoshiChintanKetankumar, et. al [22]	2015	Green Cloud Broker	Automate resource procurement to select cloud service provider	Clarke-Pivotal mechanism

III. Green Aware Elastic Resource Management Challenges

Based on the cloud on-demand need of users, the availability of cloud IaaS resources such as server, virtual machines, network equipments, bandwidth, etc, are to be allocated and managed by the service provider with the support of elasticity. Hence, elastic resource management has become as one of the salient features in cloud computing. Due to the environmental welfare of the society, the Green cloud computing has been

attracted by the research community in recent years. There are number of challenges need to be addressed, while deploying the elastic resource management in green aware cloud IaaS environment. Among them, the important challenges namely, green cloud service provider's identification/green broker, green policy making, green aware resource modeling, resource provisioning, resource allocation, identifying requirements of resources, resource scheduling and load balancing in green aware elastic resource management are analyzed in this paper.

i. Green Policy Making:

In order to reduce carbon emission, energy consumption and improve system efficiency of cloud IaaS resources, various vigour meters, sensors and policies are used to estimate the energy efficiency. Green policies are used to ensure minimum energy usage in cloud computing system or datacenters. Various existing green policies are shown in figure 4. Moreover, cloud users are motivated to use resources during non-peak hours by offering various pricing offers, incentives by green cloud provider based on the data of carbon emission directory. To achieve better efficiency, green broker uses policies for scheduling [31]. These policies named such as Greedy Minimum Carbon Emission (GMCE), Minimum Carbon Emission - Minimum Carbon Emission (MCE-MCE), Minimizing Carbon Emission and Maximizing Profit (MCE-MP), Greedy Maximum Profit (GMP) and Minimizing Carbon Emission and Maximizing Profit (MCE-MP). Developing a green aware cloud elastic resource provisioning policies is still an open challenge in both Cloud and Mobile Cloud environment.

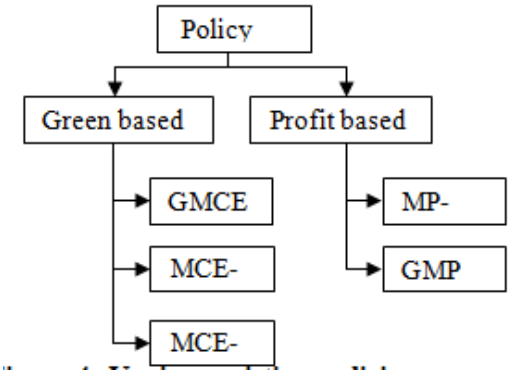

Figure 4: Various existing policies

ii. Green Cloud Service Provider's Identification by Green Broker:

On behalf of cloud user request, green broker middleware is used to select the suitable green enabled cloud service providers among the service providers. The green enabled cloud service providers can provide/update their service information like Power Usage Effectiveness (PUE), datacenter cooling efficiency, network cost, data transfer cost and carbon emission rate in carbon emission directory which is accessed by green broker. The green broker selects the cloud service provider who has least carbon emission to cloud users. To make the centralized green broker is one of the challenging tasks for resource provisioning in green cloud computing environment.

iii. Green Aware Elastic Resource Modeling:

In order to enhance green computing in cloud computing environment, to creating an efficient green aware elastic resource management model which considers cloud stack efficiency in every level such as applications, softwares, platforms, virtualization, network infrastructure, hardware, storage, cooling systems, renewable energy and monitoring components.

iv. Resource Management:

Resource management challenges include resource provisioning, resource allocation, resource adaptation, resource mapping, resource estimation, resource brokering, resource scheduling, resource discovery and selection. Resource scheduling is analyzed as aware of cost, energy, efficiency, load balancing, quality-of-service and utilization. The parameters used for green aware cloud elastic resource management problem are makespan, execution time, bandwidth, priority, energy consumption, response time, workload, elasticity, availability, throughput, reliability, recover time, SLA, fault tolerance, etc. [32][33].

IV. Conclusion And Future Directions

Green cloud computing is an emerging field for green enabled research which helps to reduce power consumption, reduce heat generation and improve system efficiency. In this paper, we analyzed green cloud frameworks and presented a descriptive literature review of green cloud computing. Moreover, what are the

major challenges are available in green aware cloud elastic resource management is presented. Many green cloud frameworks for energy efficiency are presented by researchers however, green cloud computing needs to be further focused individually on cloud deployment models, service models, security and mobile cloud computing environment.

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